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Kennedy, III et al.

[11] Patent Number: 6,009,330

[45] Date of Patent: *Dec. 28, 1999

[54] **METHOD AND APPARATUS FOR CALL DELIVERY TO A MOBILE UNIT**

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[73] Assignee: **HighwayMaster Communications, Inc.**, Dallas, Tex.

[*] Notice: This patent is subject to a terminal disclaimer.

[21] Appl. No.: **09/027,829**

[22] Filed: **Feb. 18, 1998**

Related U.S. Application Data

[63] Continuation-in-part of application No. 08/279,211, Jul. 22, 1994, Pat. No. 5,513,111, and a continuation of application No. 08/406,022, Mar. 17, 1995, Pat. No. 5,734,981, which is a continuation-in-part of application No. 08/095,166, Jul. 29, 1993, abandoned, which is a continuation-in-part of application No. 07/826,521, Jan. 27, 1992, abandoned, said application No. 08/279,211, is a continuation of application No. 08/178,022, Jan. 6, 1994, Pat. No. 5,398,190, which is a continuation of application No. 07/920,644, Jul. 28, 1992, Pat. No. 5,299,132, which is a continuation of application No. 07/642,436, Jan. 17, 1991, Pat. No. 5,155,689.

[51] **Int. Cl.**[6] **H04Q 7/38**

[52] **U.S. Cl.** **455/445**; 455/456; 455/459; 455/567

[58] **Field of Search** 455/422, 426, 455/432, 435, 445, 458, 459, 456, 461, 550, 567

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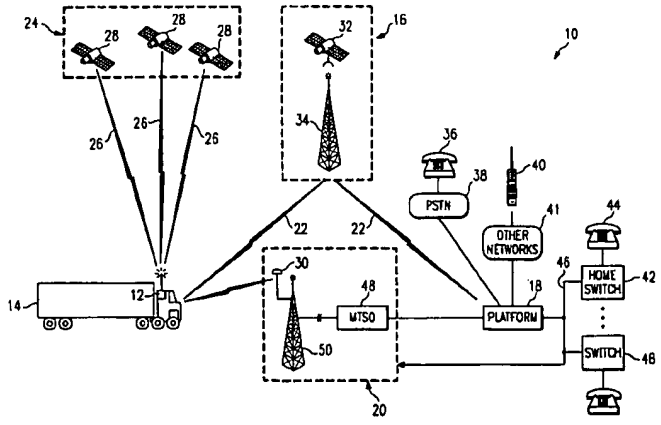
[57] **ABSTRACT**

A call delivery system (**10**) for delivering a call to a mobile unit (**12**) on a vehicle (**14**) includes both a data communications network (**16**) and a mobile voice communications network (**20**). The mobile unit (**12**) generates call delivery information and communicates this information to a platform (**18**) using the data communications network (**16**). The platform (**18**) receives a call for the mobile unit (**12**). The platform (**18**) retrieves call delivery information received from the mobile unit (**12**) and establishes communications between the platform (**18**) and the mobile unit (**12**) using the mobile voice communications network (**20**). The platform then completes the call between the caller (**36, 40, 44**) and the mobile unit (**12**). Alternatively, the platform (**18**) can generate a call back message for transmission to the mobile unit (**12**) using the data communications network (**16**).

17 Claims, 6 Drawing Sheets



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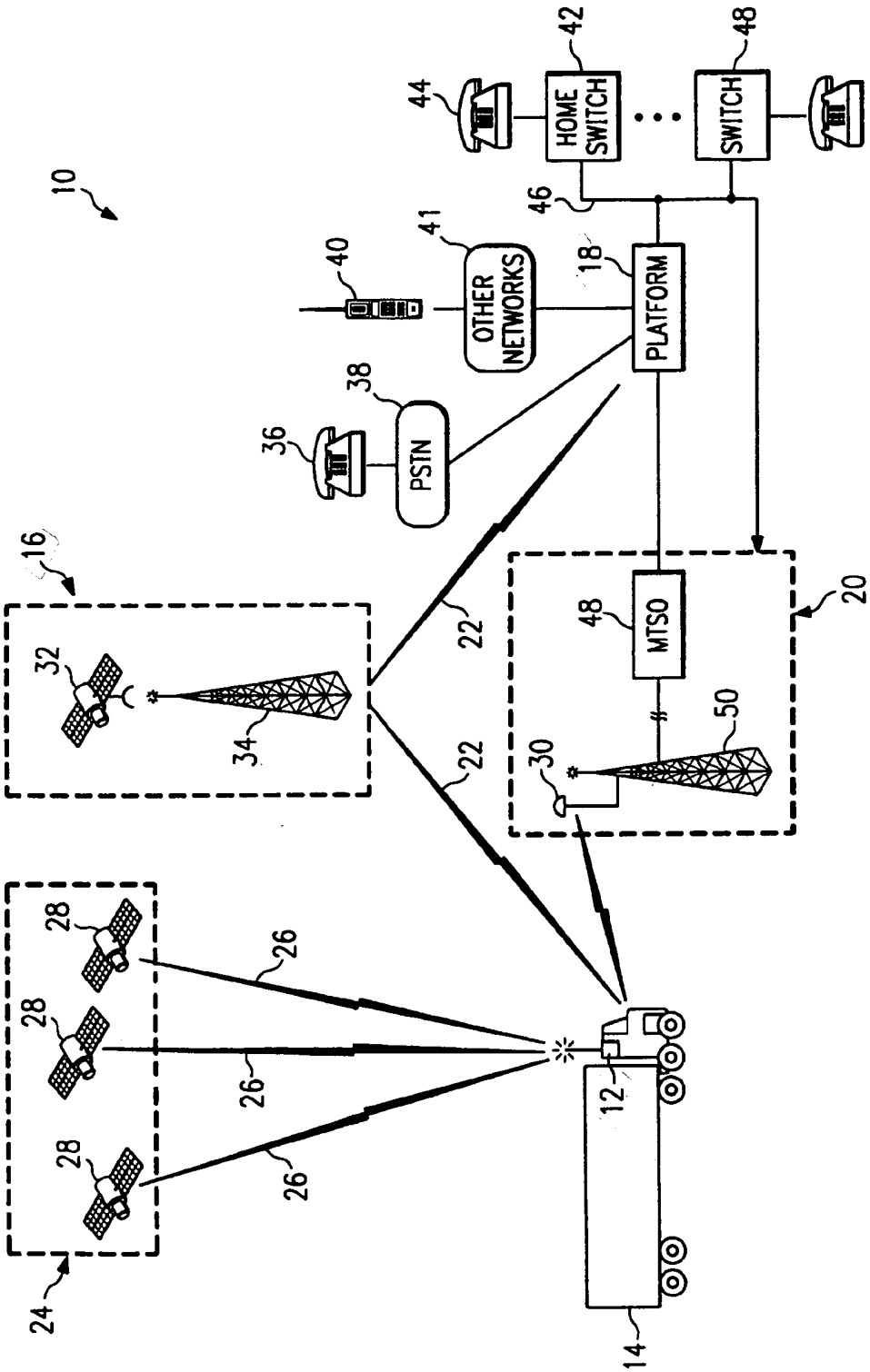
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42
HOME SWITCH
48
SWITCH
44
46
41
OTHER NETWORKS
40
18
PLATFORM
38
PSTN
36
16
32
34
22
22
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MTSO
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30
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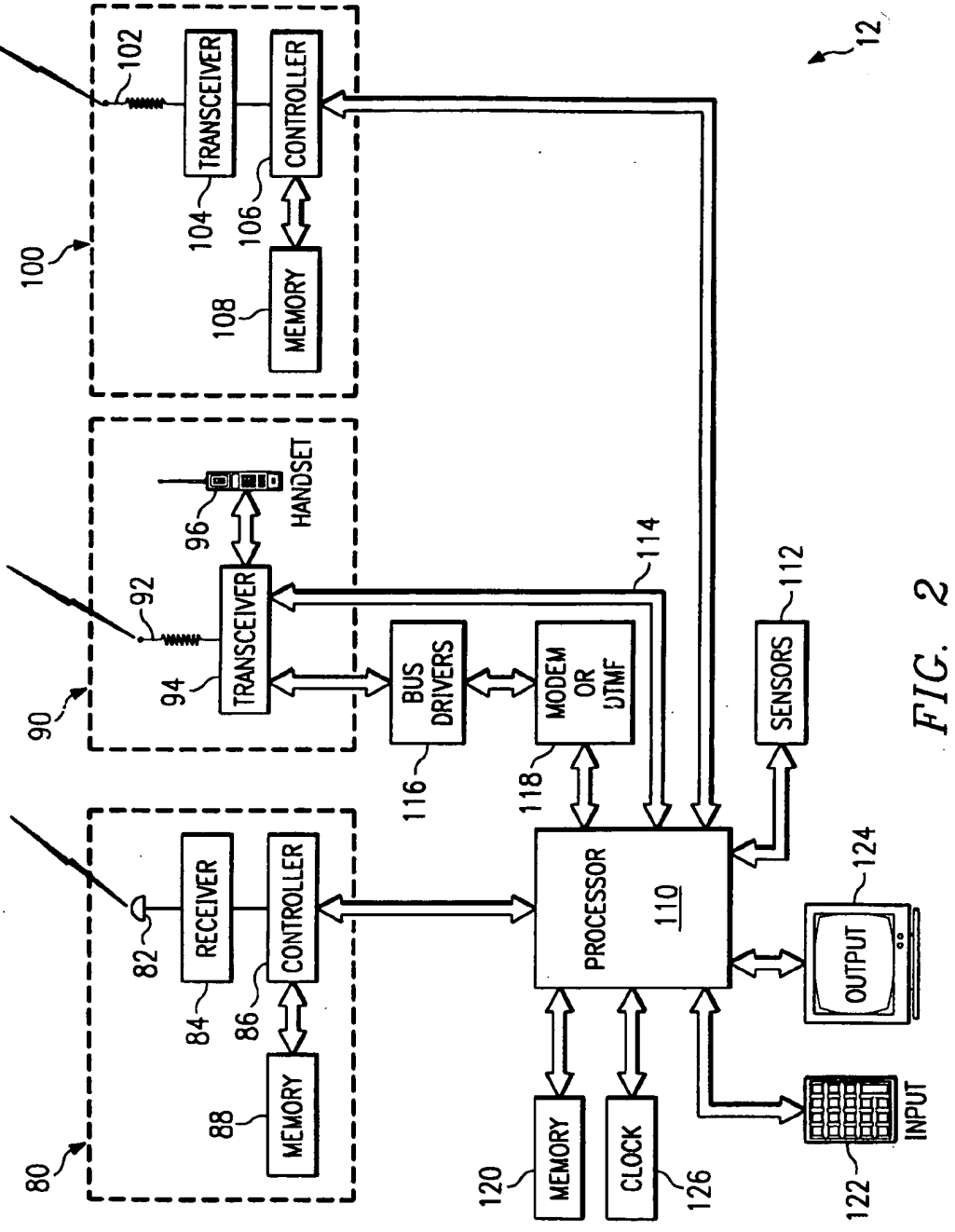
12
14
24

FIG. 1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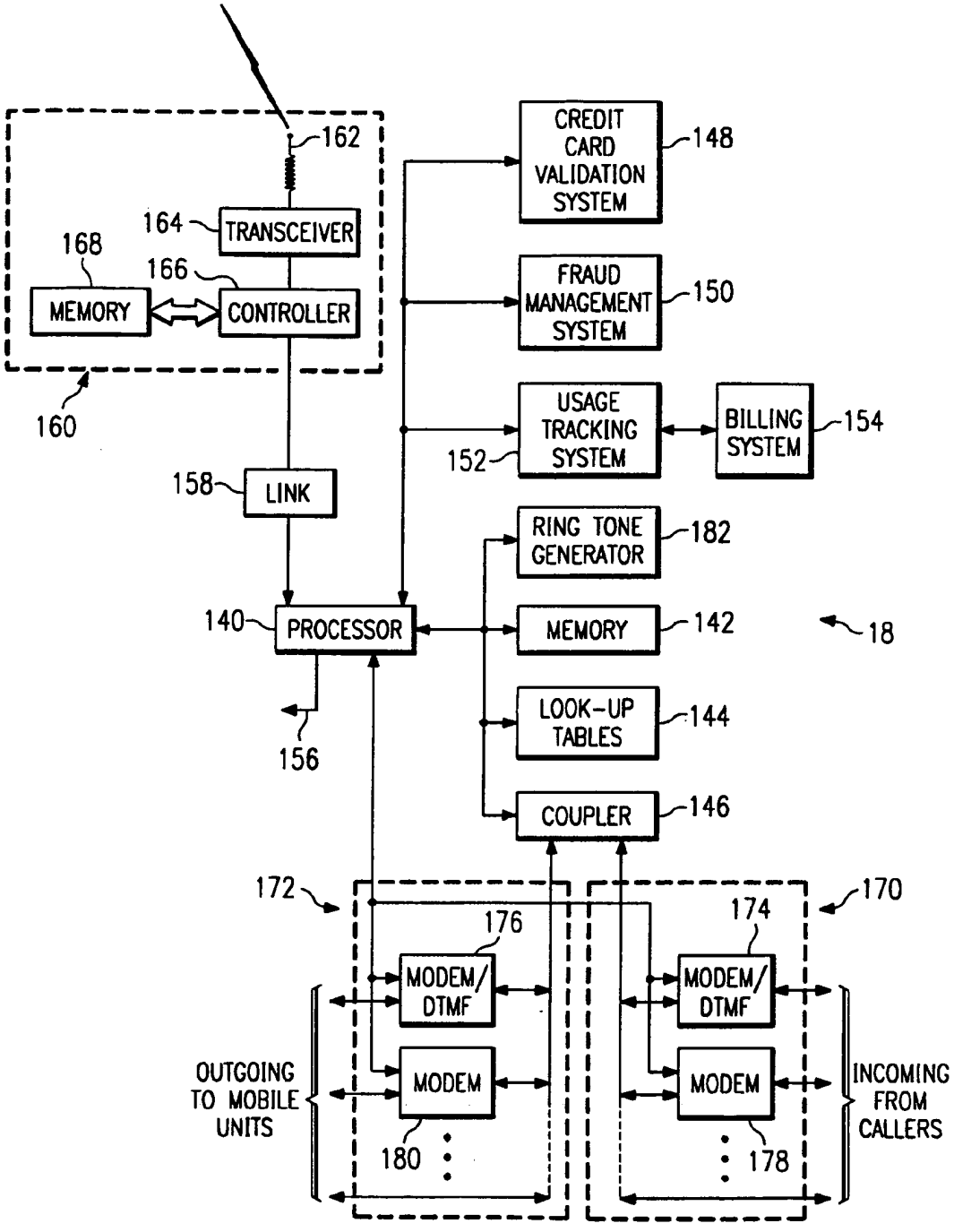
100
102
TRANSCEIVER
CONTROLLER
104
106
108
MEMORY
90
92
94
HANDSET
96
TRANSCEIVER
114
112
BUS DRIVERS
MODEM OR UTMF
SENSORS
116
118
80
82
RECEIVER
CONTROLLER
84
86
88
MEMORY
PROCESSOR 110
124
OUTPUT
INPUT
120
MEMORY
CLOCK
126
122

FIG. 2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TRANSCEIVER
168
166
MEMORY
CONTROLLER
160
158
LINK
140
PROCESSOR
156
CREDIT CARD VALIDATION SYSTEM
148
FRAUD MANAGEMENT SYSTEM
150
USAGE TRACKING SYSTEM
152
BILLING SYSTEM
154
RING TONE GENERATOR
182
MEMORY
142
18
LOOK-UP TABLES
144
COUPLER
146
172
170
176
174
MODEM/ DTMF
MODEM/ DTMF
MODEM
MODEM
OUTGOING TO MOBILE UNITS
INCOMING FROM CALLERS
180
178

FIG. 3

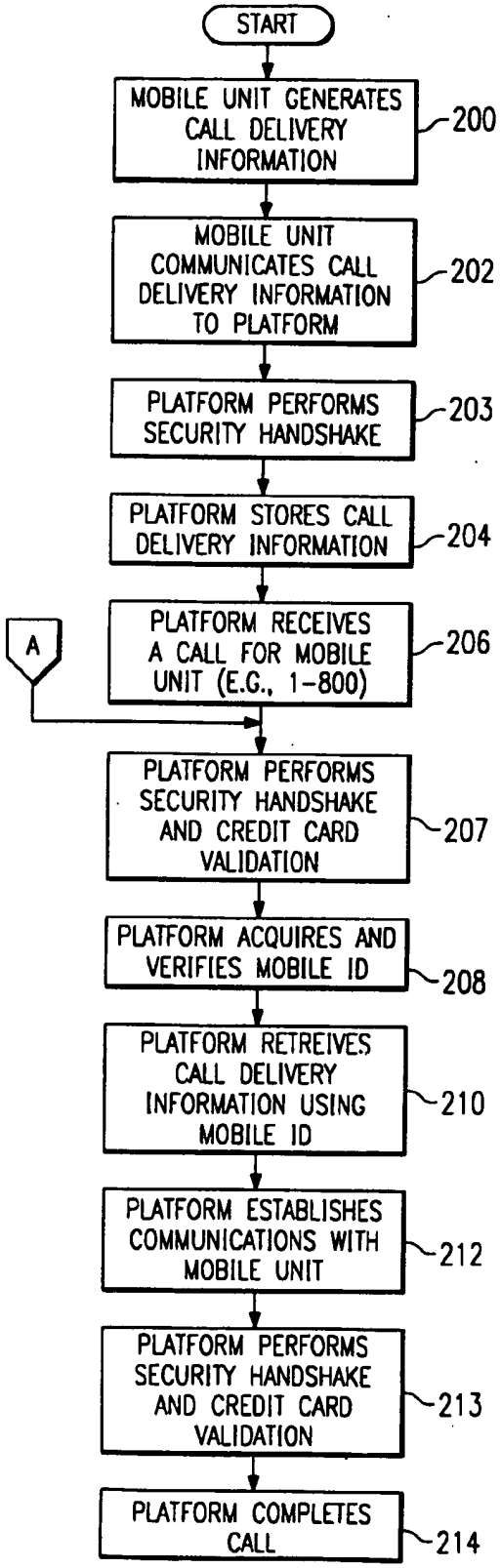
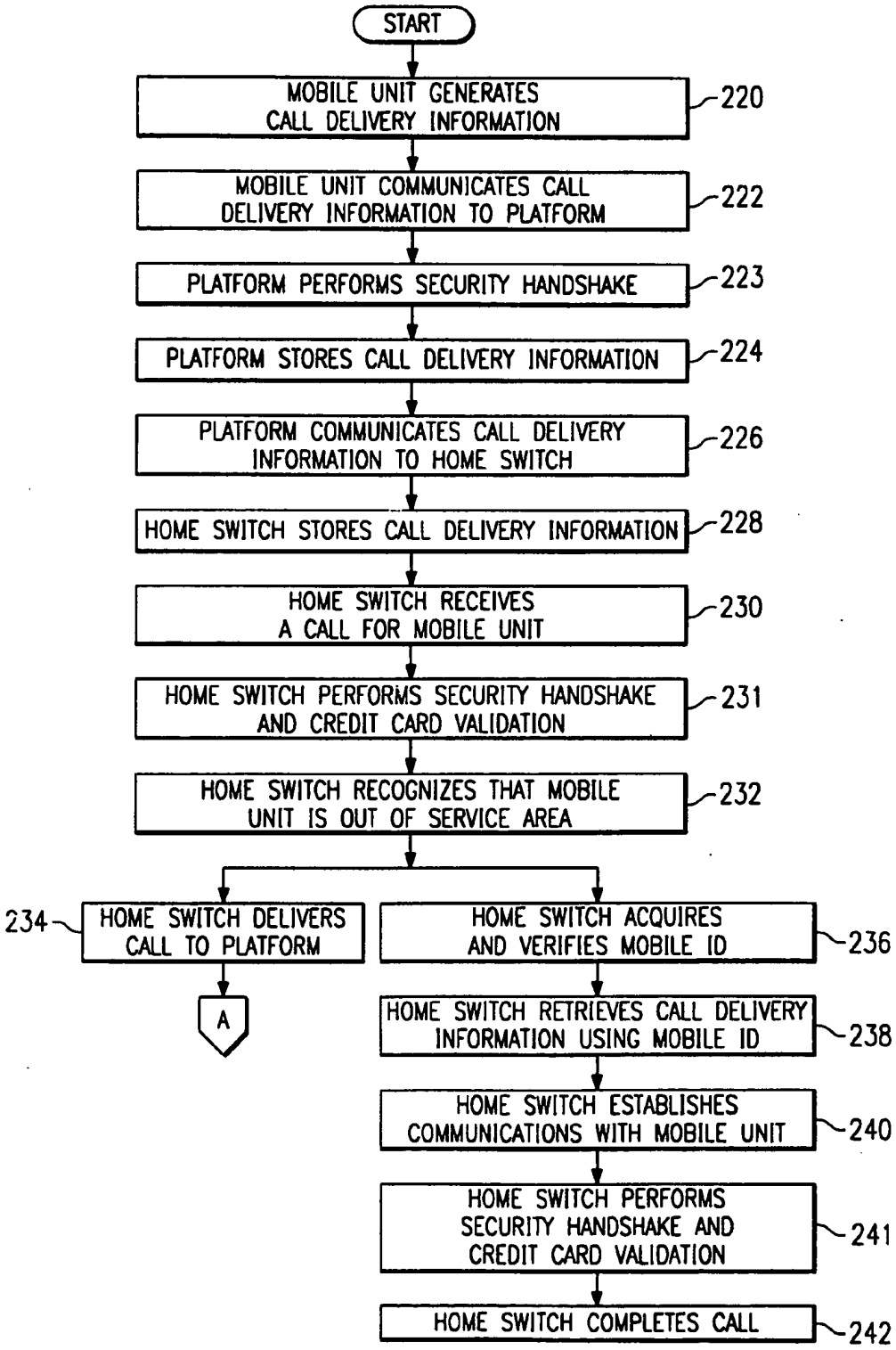

START
MOBILE UNIT GENERATES CALL DELIVERY INFORMATION
200
MOBILE UNIT COMMUNICATES CALL DELIVERY INFORMATION TO PLATFORM
202
PLATFORM PERFORMS SECURITY HANDSHAKE
203
PLATFORM STORES CALL DELIVERY INFORMATION
204
A
PLATFORM RECEIVES A CALL FOR MOBILE UNIT (E.G., 1-800)
206
PLATFORM PERFORMS SECURITY HANDSHAKE AND CREDIT CARD VALIDATION
207
PLATFORM ACQUIRES AND VERIFIES MOBILE ID
208
PLATFORM RETREIVES CALL DELIVERY INFORMATION USING MOBILE ID
210
PLATFORM ESTABLISHES COMMUNICATIONS WITH MOBILE UNIT
212
PLATFORM PERFORMS SECURITY HANDSHAKE AND CREDIT CARD VALIDATION
213
PLATFORM COMPLETES CALL
214

FIG. 4

FIG. 5


START
MOBILE UNIT GENERATES CALL DELIVERY INFORMATION
220
MOBILE UNIT COMMUNICATES CALL DELIVERY INFORMATION TO PLATFORM
222
PLATFORM PERFORMS SECURITY HANDSHAKE
223
PLATFORM STORES CALL DELIVERY INFORMATION
224
PLATFORM COMMUNICATES CALL DELIVERY INFORMATION TO HOME SWITCH
226
HOME SWITCH STORES CALL DELIVERY INFORMATION
228
HOME SWITCH RECEIVES A CALL FOR MOBILE UNIT
230
HOME SWITCH PERFORMS SECURITY HANDSHAKE AND CREDIT CARD VALIDATION
231
HOME SWITCH RECOGNIZES THAT MOBILE UNIT IS OUT OF SERVICE AREA
232
234
HOME SWITCH DELIVERS CALL TO PLATFORM
A
HOME SWITCH ACQUIRES AND VERIFIES MOBILE ID
236
HOME SWITCH RETRIEVES CALL DELIVERY INFORMATION USING MOBILE ID
238
HOME SWITCH ESTABLISHES COMMUNICATIONS WITH MOBILE UNIT
240
HOME SWITCH PERFORMS SECURITY HANDSHAKE AND CREDIT CARD VALIDATION
241
HOME SWITCH COMPLETES CALL
242

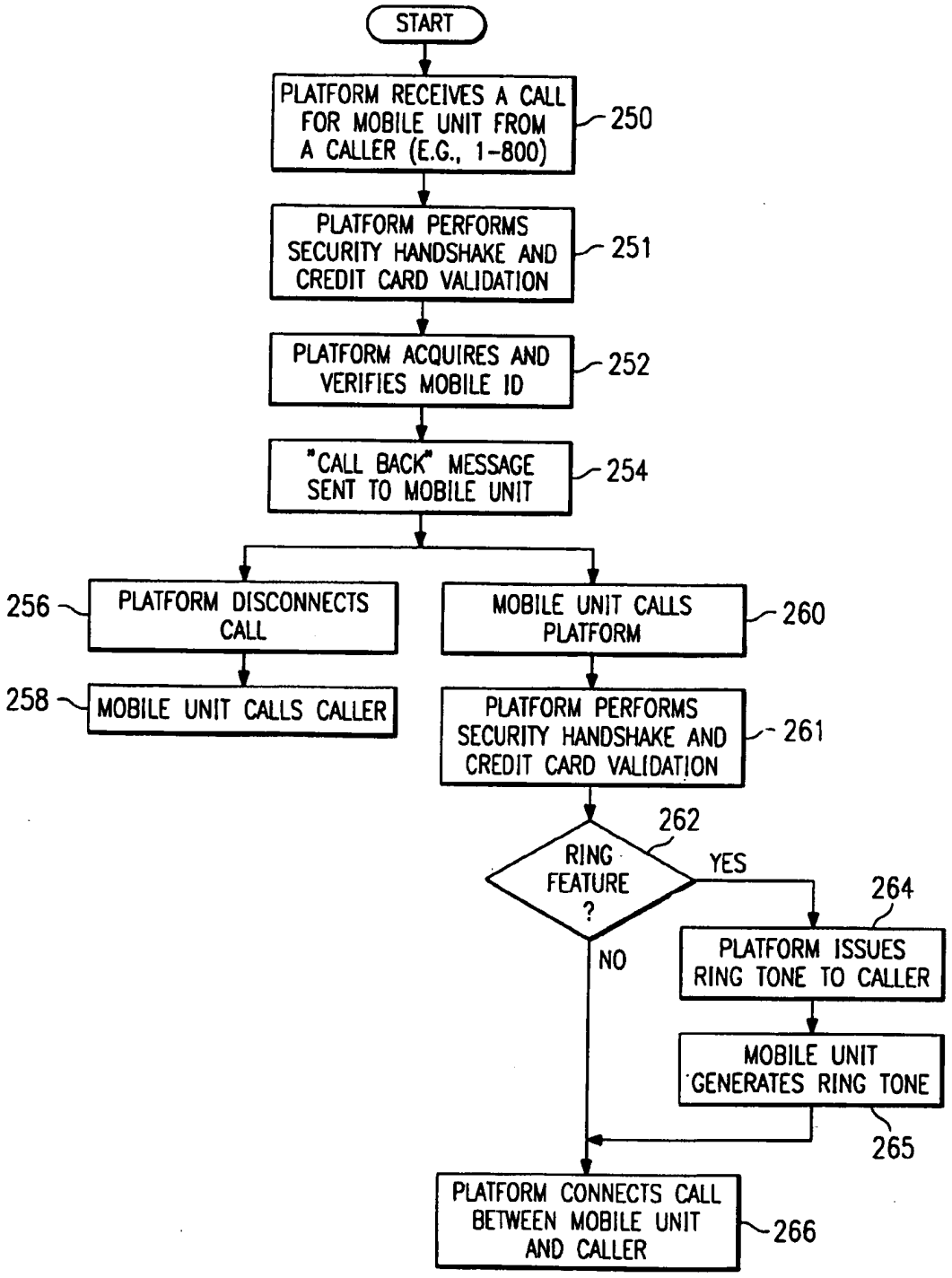

START
PLATFORM RECEIVES A CALL FOR MOBILE UNIT FROM A CALLER (E.G., 1-800)
250
PLATFORM PERFORMS SECURITY HANDSHAKE AND CREDIT CARD VALIDATION
251
PLATFORM ACQUIRES AND VERIFIES MOBILE ID
252
"CALL BACK" MESSAGE SENT TO MOBILE UNIT
254
256
PLATFORM DISCONNECTS CALL
258
MOBILE UNIT CALLS CALLER
MOBILE UNIT CALLS PLATFORM
260
PLATFORM PERFORMS SECURITY HANDSHAKE AND CREDIT CARD VALIDATION
261
262
RING FEATURE ?
YES
NO
264
PLATFORM ISSUES RING TONE TO CALLER
MOBILE UNIT GENERATES RING TONE
265
PLATFORM CONNECTS CALL BETWEEN MOBILE UNIT AND CALLER
266

FIG. 6

METHOD AND APPARATUS FOR CALL DELIVERY TO A MOBILE UNIT

RELATED APPLICATIONS

This application is a continuation application of U.S. application Ser. No. 08/406,022, filed Mar. 17, 1995 and entitled "Method and Apparatus for Call Delivery to a Mobile Unit," U.S. Pat. No. 5,734,981, which is a continuation-in-part application of U.S. patent application Ser. No. 08/095,166, entitled "Method and Apparatus for a Nation-Wide Cellular Telephone Network," filed on Jul. 29, 1993, now abandoned, and assigned to HM Holding Corporation of Dallas, TX, which is a continuation-in-part application of U.S. patent application Ser. No. 07/826,521, entitled "Phantom Mobile Identification Number Method and Apparatus," filed on Jan. 27, 1992 and assigned to By-Word Technologies, Inc. of Dallas, TX, now abandoned.

This application is also a continuation-in-part application of U.S. patent application Ser. No. 08/279,211, entitled "Vehicle Locating and Communicating Method and Apparatus," filed on Jul. 22, 1994, U.S. Pat. No. 5,513,111, which is a continuation application of U.S. patent Ser. No. 08/178,022, entitled "Vehicle Locating and Communicating Method and Apparatus," filed Jan. 6, 1994, now U.S. Pat. No. 5,398,190, which is a continuation application of U.S. patent application Ser. No. 07/920,644, entitled "Vehicle Locating and Communicating Method and Apparatus," filed on Jul. 28, 1992, now U.S. Pat. No. 5,299,132, which is a continuation of U.S. patent application Ser. No. 07/642,436, entitled "Vehicle Locating and Communicating Method and Apparatus," filed on Jan. 17, 1991, now U.S. Pat. No. 5,155,689.

TECHNICAL FIELD OF THE INVENTION

This invention relates generally to the field of telecommunications, and more particularly to a method and apparatus for call delivery to a mobile unit.

BACKGROUND OF THE INVENTION

Mobile voice communications technology has enjoyed substantial growth over the past decade. Many cars, trucks, airplanes, boats, and other vehicles are equipped with devices that allow convenient and reliable mobile voice communications using a network of satellite-based or land-based transceivers. Advances in this technology have led to widespread use of mobile units, such as hand-held or vehicle-mounted cellular telephones, for voice communications.

Many users of mobile units desire continuous and reliable service as they travel across long distances. For example, a cellular telephone in a vehicle or carried by a person may travel through many different cellular systems offering a range of subscriber features. Calls placed to these roaming phones must be routed to the current communications service provider. Traditional roaming technology delivers calls placed to these roaming phones using the communications infrastructure of the cellular telephone network. Typically, the roaming phone registers with a communications service provider and notifies the home communications service provider of the registration.

The roaming services provided through the cellular telephone infrastructure introduce additional complexity and communications traffic in the system and come at a substantial cost to the end user. The communications service providers utilize additional equipment and communications bandwidth to register roamers and report the registration to the home switch of the roaming phone. Users are charged a premium for these services.

SUMMARY OF THE INVENTION

In accordance with the present invention, the disadvantages and problems associated with previous techniques used to deliver calls to a mobile unit has been substantially reduced or eliminated. One aspect of the present invention provides a system for delivering a call to a mobile unit that utilizes a data communications network for communicating call delivery information.

According to an embodiment of the present invention, a system for delivering a voice call to a mobile unit includes a mobile voice communications network and a data communications network. The mobile unit includes a data transmitter coupled to the data communications network that communicates call delivery information using the data communications network. The mobile unit also includes a mobile voice communications transceiver coupled to the mobile voice communications network. A platform coupled to the data communications network and the mobile voice communications network includes a data receiver that receives call delivery information communicated by the data transmitter of the mobile unit. The platform receives the voice call and delivers the voice call, in response to the call delivery information received by the data receiver, to the mobile voice communications transceiver of the mobile unit.

According to another embodiment of the present invention, a method for delivering a voice call to a mobile unit includes generating call delivery information at the mobile unit. The mobile unit communicates the call delivery information to a platform using a data communications network. A voice call for the mobile unit is received at the platform. A communications link is established, in response to the call delivery information received from the mobile unit, between the platform and the mobile unit using a mobile voice communications network. The voice call is coupled to the communications link.

Important technical advantages of the present invention include the integration of a data communications network to provide call delivery information for a mobile voice communications network. Numerous technologies, including both satellite-based and land-based data messaging systems, may be integrated with a mobile voice communications network to provide call delivery information. One or more of these data communications technologies support inexpensive and dependable call delivery to roaming subscribers. Another technical advantage includes reducing the communications traffic and complexity of existing mobile voice communications networks. For example, the cellular telephone network devotes considerable communications bandwidth and equipment to support the registration and notification of roaming subscribers. The present invention offloads much of the roaming support services to existing data communications technology, which provide either centralized or distributed control of call delivery functions. The present invention also reduces the expenses associated with the mobile voice communications network, for both the communications service provider and the roaming subscriber. The system achieves significant cost savings by utilizing existing, inexpensive data communications technology to reduce the traffic and complexity of the mobile voice communications network. Important technical advantages also include a reduction in roamer fraud through centralized control of call delivery services. Other technical

advantages are readily apparent to one skilled in the art from the following figures, description, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and for further features and advantages, reference is now made to the following description taken in conjunction with the accompanying drawings, wherein like reference numerals represent like parts, in which:

FIG. **1** illustrates a system for delivering calls to a mobile unit;

FIG. **2** is a schematic representation of a mobile unit;

FIG. **3** is a schematic representation of a platform for delivering calls to the mobile unit;

FIG. **4** is a flow chart of a method for delivering a call to a mobile unit;

FIG. **5** is a flow chart of a method for delivering a call placed at a home switch to a mobile unit; and

FIG. **6** is a flow chart of a method for requesting a call back from the mobile unit.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** illustrates a call delivery system **10** that delivers a call to mobile unit **12** on vehicle **14**. Call delivery system **10** includes mobile unit **12**, a data communications network **16**, a platform **18**, and a mobile voice communications network **20**. In operation, mobile unit **12** communicates call delivery information to platform **18** using data communications network **16**. Platform **18** delivers a call to mobile unit **12** over mobile voice communications network **20** using the call delivery information. In an alternative operation, platform **18** communicates a call back message to mobile unit **12** using data communications network **16**.

Mobile unit **12** is shown on vehicle **14**, however, mobile unit **12** may be carried by all types of vehicles, including cars, trucks, airplanes, boats, barges, railcars, truck trailers, or on a person's body, along with a package, or with any other movable object benefitting from mobile communications services. As described in more detail in FIG. **2**, mobile unit **12** includes both a data transceiver for communicating call delivery information and a transceiver for conducting a call over mobile voice communications network **20**.

In one embodiment, mobile unit **12** initiates the call delivery process by generating call delivery information and delivering this information over data link **22** of data communications network **16** to platform **18**. Call delivery information represents any information that allows platform **18** to deliver calls to mobile unit **12**. For example, call delivery information includes information relating to the communications service provider in mobile voice communications network **20** that currently services mobile unit **12**. This information includes a system identification number (SID), a mobile serving carrier I.D. (MSCID), a switch I.D. (SWID), or any other identifier of the communications service provider. Furthermore, call delivery information can be an access number for the communications service provider, such as a number for a roamer access port (RAP). Another form of call delivery information relating to the communications service provider is rural service area (RSA) information or information associated with automatic registration under the IS-41 standard, such as a temporary local dialing number (TLDN). This type of call delivery information relating to the communications service provider of mobile unit **12** may be used by platform **18** to either directly or indirectly deliver a call to mobile unit **12**.

Call delivery information also includes positional information of mobile unit **12**. Mobile unit **12** equipped with a positioning receiver may obtain position information from a satellite-based or land-based positioning system **24**. Mobile unit **12** receives position information over position information streams **26** from a plurality of satellites **28**. The position information comprises accurate satellite location information and pseudorange data represented by the time of arrival of position information streams **26** to mobile unit **12**.

Positioning system **24** is illustrated as a satellite-based radio navigation system such as the NAVSTAR global positioning system (GPS). The NAVSTAR GPS is a representative positioning system **24**, but any land-based or satellite-based system may be used. For example, positioning system **24** may be a land-based LORAN-C, a space-based GLONASS, or any other system using radio frequency (RF) triangulation positioning technology. Positioning system **24** can represent spaced-based or land-based transmitters that emit position information. In addition, positioning system **24** can be a network of roadside positional tags that can be detected by a reading device on vehicle **14**.

Satellites **28** maintain accurate and synchronized time and simultaneously transmit position information that contains satellite specific and system information. The position information transmitted by satellites **28** includes high precision clock and ephemeris data for a particular satellite, low precision clock and ephemeris data for every satellite in a constellation ("almanac data"), health and configuration status for all satellites, user text messages, and other parameters describing operation of positioning system **24**.

Positioning system **24** can include additional satellites and one or more positioning receivers. In one embodiment, a positioning receiver **30** mounted on transmitter **50** in mobile voice communications network **20** implements differential GPS techniques. Positioning receiver **30** generates correction data that enables mobile unit **12** to more accurately determine the position of vehicle **14**. Positioning receiver **30** transmits the correction data to mobile unit **12** over any suitable link, including a link supported by mobile voice communications network **20**.

Mobile unit **12** can also generate position information using an on-board positioning sensor. For example, an inertial navigation sensor on vehicle **14** integrates accelerations imparted to vehicle **14** to determine current position. A dead reckoning sensor computes vehicle location based on compass orientation and distance travelled at that orientation. A dead reckoning sensor of vehicle **14** includes a direction finder, such as a compass, integrated with a distance sensor, such as an odometer or tire rotation counter, to track the location of vehicle **14** and determine its current position. Mobile unit **12** can also include a device to read roadside positional tags to determine location of vehicle **14**.

Mobile unit **12** compiles call delivery information, either relating to the communications service provider of mobile unit **12** or positional information of mobile unit **12** or vehicle **14**, into a call delivery information report. To minimize costs and to reduce load on data communications system **16**, the call delivery information report should be as brief as possible. Mobile unit **12** can either send the raw call delivery information or pre-process this information to further reduce the report size. Platform **18** can further process the received call delivery information based on the processing already performed by mobile unit **12**, the nature of the call delivery information, and other considerations. The present invention contemplates any arrangement and coordination of call

delivery information processing tasks between mobile unit **12** and platform **18**.

Mobile unit **12** communicates the call delivery information report over data link **22** of data communications network **16** to platform **18**. Data communications network **16** represents any type of data messaging network, using land-based or spaced-based transceivers, repeaters, or transmitters, that supports communication of data from mobile unit **12** to platform **18**. A spaced-based data messaging system uses one or more satellites **32** that receive communications from mobile unit **12** and retransmit the communications to platform **18**. The satellites may be in geostationary orbit, low earth orbit (LEO), or any other configuration, and may utilize any suitable frequency band of communications. A land-based data communications network includes one or more land-based transmitters **34** that communicate data over dedicated or public switched data lines. For example, land-based transmitter **34** may be a component of the land-line or mobile public switched telephone network (PSTN), a communication link such as a T1 trunk, the SS7 backbone infrastructure of the PSTN, a private data network, or any other suitable data communications network. Data communications network **16** represents one or a combination of the data messaging technologies discussed above.

In one embodiment of the present invention, data communications network **16** operates separately and independently from mobile voice communications network **20**. For example, call delivery system **10** can use a satellite-based data messaging system for communicating call delivery information to deliver a voice call using the cellular telephone network. Using one system for communicating data and another system for conducting voice communications provides several advantages. One or a combination of data messaging technologies mentioned above provide inexpensive communications of call delivery information throughout the country. Call delivery information can be communicated to platform **18** using these technologies at a fraction of the cost of current roamer services provided by the cellular telephone network. Furthermore, the use of a separate network to manage call delivery information reduces or eliminates the complexity and expense of roamer registration and reporting features in mobile voice communications network **20**.

Current roamer registration and notification procedures increase the already crowded communications channels in the cellular telephone network, and require additional equipment and expense to operate. Furthermore, different cellular telephone systems offer different roaming subscriber support, which further complicates integration of registration and reporting services among systems. For example, some of the larger cellular telephone systems offer automatic roamer registration using the IS-41 standard, while smaller and rural providers only support manual registration. The present invention provides consistent and dependable call delivery services through the use of a separate data communications network **16** and platform **18** without increasing the cost or complexity of mobile voice communications network **20**.

The choice of a proper data communications technology depends on several considerations. The chosen data communications network **16** should provide coverage in areas travelled by mobile unit **12**. In addition, data communications network **16** should provide inexpensive data communications that can handle relatively small data packages containing call delivery information. Based on these constraints of coverage area and expense, call delivery system **10** can use one or a combination of the data communications technologies mentioned above.

Upon receipt of call delivery information transmitted by mobile unit **12** over data communications network **16**, platform **18** stores the call delivery information for later retrieval. Platform **18** stores call delivery information indexed by or identified with a particular mobile unit **12**. Over time, platform **18** constructs a table containing time-stamped call delivery information reports associated with a particular mobile unit **12**.

Platform **18** receives a call for mobile unit **12** from a variety of sources. The call can originate from a caller **36** of the public switched telephone network (PSTN) **38**. PSTN **38** includes the traditional land-line telephone network and the network of cellular telephone systems. Using PSTN **38**, caller **36** directs the call to platform **18** by inputting a traditional telephone number associated with platform **18** or mobile unit **12**. In one embodiment, caller **36** inputs a 1+800 number to connect to platform **18**.

A caller **40** can initiate calls to mobile unit **12** using other communications networks **41**, such as a specialized mobile radio (SMR), enhanced specialized mobile radio (ESMR), a personal communications service (PCS), a citizens band (CB), a dedicated radio system, such as those used by police and firefighters, or any other suitable communications link that allows caller **40** to direct a call to platform **18**.

Generally, platform **18** couples with PSTN **38** and other networks **41** to receive calls for mobile unit **12** from callers **36** and **40**. Platform **18** also communicates with specific components of PSTN **38** to facilitate call delivery. Platform **18** communicates with a home switch **42** of mobile unit **12**. In one embodiment, a caller **44** dials a number associated with mobile unit **12**, which is received by home switch **42**. Home switch **42** recognizes that mobile unit **12** is out of its service area and transfers the call to platform **18** over a suitable link **46**. This allows caller **44** to directly dial a traditional telephone number for mobile unit **12** and still benefit from call delivery system **10**.

Platform **18** can provide home switch **42** with call delivery information received from mobile unit **12** over link **46**. Home switch **42** can use this call delivery information received from platform **18** to deliver a call to mobile unit **12** placed by caller **44** without additional assistance from platform **18**. Other switches **48** also receive call delivery information from platform **18** in a similar manner as home switch **42**.

It should be understood that the present invention contemplates integration of the components and functionality of platform **18**, home switch **42**, and switch **48**. In particular, platform **18** can be integrated or associated with home switch **42**, and operate to receive and store call delivery information reports for later retrieval by home switch **42**. Platform **18** can also implement other more advanced telecommunications features, such as those offered by a central office (CO) or mobile telecommunications switching office (MTSO) of PSTN **38**. Call delivery system **10** supports calls placed to mobile unit **12** from a variety of callers **36**, **40**, and **44**, collectively represented by an exemplary caller **36**, using a variety of communications technology. Furthermore, platform **18** itself can initiate calls to mobile unit **12**.

After receiving a call for mobile unit **12** from caller **36**, platform **18** retrieves the most recent call delivery information received from mobile unit **12**. Depending on the type of call delivery information, platform **18** either immediately establishes voice communications with mobile unit **12** or performs a further database look-up or other processing to

determine the communications service provider of mobile unit **12** and the proper procedure for establishing voice communications. If the call delivery information is a position of mobile unit **12** or vehicle **14**, platform **18** relates the position to a communications service provider. Platform **18** maintains a list of MSCIDs, SIDs, SWIDs, NPAs, RAPs, and other communications service provider identifiers, correlated with geographical service area, to determine the proper access number and calling procedure to establish a communications link with mobile unit **12**.

Platform **18** can also extrapolate or predict the position of vehicle **14** to produce an estimated vehicle position. This estimation can be based on the expected route of vehicle **14**, its intended destination, or other parameters impacting the route and travel time of vehicle **14**. Platform **18** can use data stored in its memory to calculate an estimated vehicle position, or data for calculation can be transmitted from mobile unit **12** to platform **18** either separately or along with the call delivery information report. Platform **18** determines the proper access number and calling procedure to establish a communications link with mobile unit **12** based on the estimated position of vehicle **14**. Furthermore, platform **18** can periodically compute an estimated position of vehicle **14** and generate an in-service signal that indicates that the estimated position of vehicle **14** is within the service area of mobile voice communications network **20**.

After determining the access number and calling procedure, platform **18** establishes communications with mobile unit **12** over mobile voice communications network **20**. Platform **18** directly dials mobile unit **12** if it has received or can compute a direct dial number for mobile unit **12**. In other cases, platform **18** establishes a communications link with mobile unit **12** through a two-step dialing method using a RAP or other communications port of the communications service provider of mobile unit **12**. Using the RAP, platform **18** dials the communications service provider, receives a new dial tone, and then dials the specific number for mobile unit **12**.

Mobile voice communications network **20** represents any technology that supports mobile voice communications. Mobile voice communications network **20** can be the cellular telephone network, or any other satellite-based or land-based mobile voice communications network, such as a specialized mobile radio (SMR), an enhanced specialized mobile radio (ESMR), a personal communications service (PCS), a citizens band (CB), a dedicated radio system, such as those used by police and firefighters, or any other suitable mobile voice communications system. In the specific example of a cellular telephone network, mobile voice communications network **20** includes a mobile telecommunications switching office (MTSO) **48** coupled to a cellular transmitter **50** servicing mobile unit **12**.

In another embodiment, platform **18** initiates the call delivery process upon receiving a call from caller **36** for mobile unit **12**. Using the data communications network **16**, platform **18** communicates a call back message to mobile unit **12**. This call back message can be directed to mobile unit **12** based on location information stored at platform **18**, or the call back message can be broadcast over data communications network **16** without knowing the location of mobile unit **12**. For example, some data communications technologies may require an exact or approximate position of mobile unit **12** to deliver the call back message, whereas other data communications technologies, such as paging systems, can deliver a call back message without location information of mobile unit **12**. The call back message can request mobile unit **12** to call platform **18** or caller **36** directly.

In operation of one embodiment of call delivery system **10**, mobile unit **12** generates call delivery information relating to its position or its communications service provider. Mobile unit **12** communicates the call delivery information to platform **18** using data link **22** of data communications network **16**. Platform **18** stores the call delivery information and awaits a call for mobile unit **12**. Upon receiving a call from caller **36**, platform **18** retrieves the most recently reported call delivery information for mobile unit **12**. Platform **18** uses the call delivery information to establish a communications link between platform **18** and mobile unit **12** using mobile voice communications network **20**. Upon establishing a communications link, platform **18** connects the call from caller **36** to mobile unit **12**.

In operation of another embodiment of call delivery system **10**, platform **18** receives call delivery information from mobile unit **12** over data link **22** and provides this call delivery information to home switch **42** over link **46**. Home switch **42** then utilizes the call delivery information in a similar fashion as described by platform **18**, and directly delivers the call to mobile unit **12** over mobile voice communications network **20**. Similarly, platform **18** can provide call delivery information to other switches **48** that receive calls to be delivered to mobile unit **12**.

In operation of another embodiment of call delivery system **10**, platform **18** receives a call for mobile unit **12** from caller **36**. Using data link **22** of data communications network **16**, platform **18** transmits a call back message to mobile unit **12**, specifying mobile unit **12** to call platform **18** or caller **36** directly. If mobile unit **12** calls platform **18**, then the call from caller **36** and the call from mobile unit **12** are coupled to complete call delivery. Platform **18** and mobile unit **12** can generate ring tones to simulate a direct call from caller **36** to mobile unit **12**, as explained below with reference to FIG. **6**.

FIG. **2** is a schematic representation of mobile unit **12**. Mobile unit **12** includes mobile positioning receiver **80**, mobile voice communications device **90**, data transceiver **100**, and other associated hardware and software, described below.

Mobile positioning receiver **80** includes antenna **82**, receiver **84**, controller **86**, and memory **88**. In operation, mobile positioning receiver **80** receives position information from satellites **28** over position information streams **26** at antenna **82**. Receiver **84** processes the position information to extract ephemeris, almanac, and clock correction data. Controller **86** receives the position information and, optionally, directly computes a vehicle position. These calculations performed by controller **86** may use data or operational software stored in memory **88**. The vehicle position derived from information received or computed by mobile positioning receiver **80** is passed to processor **110** for generation of a call delivery information report. Alternatively, sensors **112**, such as an inertial navigation sensor, a dead-reckoning sensor, or a roadside positional tag reading device, generate vehicle position.

Mobile voice communications device **90** includes antenna **92**, transceiver **94**, and handset **96**. Mobile voice communications device **90** receives information related to the communications service provider of mobile unit **12** at antenna **92**. This information, such as an MSCID, SID, SWID, NPA, RAP, TLDN, or other information associated with the communications service provider passes through transceiver **94** over link **114** to processor **110** for generation of a call delivery information report. Alternatively, this information passes through bus drivers **116** and a modem or dual tone multifrequency (DTMF) coder/decoder **118** to processor **110**.

Antenna **92** and transceiver **94** also receive calls placed by caller **36** and delivered to mobile unit **12**, and place calls in response to a call back message received from platform **18**. The user of mobile unit **12** communicates with caller **36** over handset **96**. The delivered call to mobile unit **12** is a traditional voice call, a combination of a voice call with embedded or interleaved data, or a call to transfer data to mobile unit **12** over bus drivers **116** and modem or DTMF coder/decoder **118**. For example, mobile voice communications device **90** can receive a call over mobile voice communications network **20** to download data to processor **110** or attached memory **120**. The data to be downloaded can be updates to operational software of mobile unit **12**, messages to operator of mobile unit **12**, or other information for operation of mobile unit **12**. This information can be generated by caller **36** or platform **18**.

Data transceiver **100** includes an antenna **102**, a transceiver **104**, a controller **106**, and a memory **108**. In operation, data transceiver **100** sends and receives data from data communications network **16**. For example, processor **110** generates a call delivery information report, based on positional information received from mobile positioning receiver **80** or communications service provider information received from mobile voice communications device **90**, and passes this call delivery information report to controller **106** of data transceiver **100**. Controller **106** formats the report for transmission and transceiver **104** transmits the report over antenna **102**. Controller **106** accesses operational software or other data stored in memory **108** during operation of data transceiver **100**.

Data transceiver **100** also receives data from data communications network **16** at antenna **102**, and passes this data through transceiver **104** and controller **106** to processor **110**. For example, data transceiver **100** can receive a call back message from platform **18** and pass this message to processor **110**, which can inform operator of mobile unit **12** or initiate a call using mobile voice communications device **90** in response to the call back message. Therefore, data transceiver **100** provides data transmission and reception capabilities over data communications network **16** and directly links this information to processor **110**.

Processor **110** manages the communicating, processing, locating, and reporting features of mobile unit **12**. In one operation, processor **110** receives call delivery information from mobile positioning receiver **80** or mobile voice communications device **90** and prepares a call delivery information report. Processor **110** delivers the call delivery information report to data transceiver **100** for transmission over data communications network **16** to platform **18**. In another operation, processor **110** receives a call back message from data transceiver **100**, and initiates a call using mobile voice communications device **90**.

Memory **120** contains programs, maps, databases, and other information used by processor **110** to perform its functions. Memory **120** can be random access memory (RAM), read-only memory (ROM), CD-ROM, removable memory devices, or any other device that allows storage or retrieval of data. Processor **110** and controllers **86** and **106** as well as memories **88**, **108** and **120**, may be separate or integral components of mobile unit **12**. Mobile unit **12** contemplates any arrangement, processing capability, memory allocation, or task assignment between mobile positioning receiver **80**, mobile voice communications device **90**, data transceiver **100**, processor **110**, and memory **120**.

Processor **110** is also coupled to input device **122** and output device **124**. Input device **122** is a keypad, touch screen, voice recognition software and related hardware, or other device that can accept information, such as digital data or audible commands. Output device **124** conveys information associated with the operation of mobile unit **12**, including digital data, visual information, or audio information. Both input device **122** and output device **124** include fixed or removable storage media, such as magnetic computer disks, CD-ROM, or other suitable media to both receive output from and provide input to processor **110** or memory **120**. For example, information correlating position of mobile unit **12** to identifiers of communications service providers is provided to input device **122** and stored in memory **120**.

In one aspect of the present invention, platform **18** sends a message to data transceiver **100** requesting mobile unit **12** to call platform **18** or another party. Antenna **102** receives the call back message and passes it through transceiver **104** and controller **106** to processor **110**. Output device **124**, at the direction of processor **110**, can notify the operator of mobile unit **12** to place the requested call. For example, output device **124** can display the time of the call back message, a short message, and a telephone number for the operator to call. Alternatively, processor **110** can automatically initiate a call back using mobile voice communications device **90** without operator intervention.

The operator either manually inputs the phone number using input device **122** or handset **96**, or processor **110** directs appropriate hardware to automatically place the call to the desired number. Upon successfully placing a call with the telephone number specified in the call back message, operator of mobile unit **12** commences voice communications over handset **96**. In one embodiment, handset **96** or output device **124** can generate a ring tone after establishing communications to alert operator of mobile unit **12** of a delivered call.

Call delivery system **10** can reduce the cost and complexity of delivering calls to mobile unit **12** by minimizing the call delivery information transmitted by data transceiver **100** to platform **18**. Processor **110** collects various pieces of information from positioning receiver **80**, mobile voice communications device **90**, sensors **112**, memory **120**, input device **122**, or other sources, and distills this information into a call delivery information report for transmission over data transceiver **100**. The call delivery information report can be time-stamped using time generated by clock **126** coupled to processor **110**.

In addition to call delivery information, processor **110** and data transceiver **100** report other information to platform **18** or caller **36**. This information originates from sensors **112**, such as engine sensors, truck-trailer sensors, security monitors, on-board positioning sensors or other devices generating information on the status or condition of mobile unit **12**, vehicle **14**, or its operator. The operator can also compose a data message for transmission using input device **122**.

Components of mobile unit **12** shown in FIG. **2** are packaged in one or more housings. Mobile unit **12** mounts to vehicle **14** or an object to be tracked. Mobile unit **12** can also be packaged as a portable, hand-held device that provides personal timing, locating, communicating, and reporting functions. For example, police, firefighters, rescue teams, service and delivery personnel, individuals that may change forms of transportation, or other persons requiring portable communications can use a hand-held mobile unit **12**.

FIG. **3** illustrates a block diagram of platform **18** that delivers calls to mobile unit **12** in response to reported call

delivery information. Platform **18** also generates and delivers call back messages directing mobile unit **12** to call platform **18** or caller **36**. Platform **18** includes a processor **140** coupled to memory **142**, look-up tables **144**, and coupler **146**. Processor **140** is also coupled to credit card validation system **148**, fraud management system **150**, usage tracking system **152**, and billing system **154**. Processor **140** communicates with other similarly functioning platforms in a distributed platform embodiment or with home switch **42** or other switches **48** over communications link **156**. Communications link **156** can be a portion of the nation-wide SS7 backbone that interconnects components of PSTN **38**, or any other dedicated or switched communications link.

Platform **18** is also coupled to data transceiver **160** over link **158**. Data transceiver **160** can be integral to or separate from platform **18**. For example, data transceiver **160** can be disposed at a central messaging center of data communications network **16** which is remotely located from platform **18**. Link **158** can be any appropriate dedicated or switched link that supports communication of data between platform **18** and data transceiver **160**.

Data transceiver **160** is similar in construction and operation to data transceiver **100** in mobile unit **12**. Data transceiver **160** includes antenna **162**, transceiver **164**, controller **166**, and memory **168**. In operation, data transceiver **160** receives data messages from and transmits data messages to mobile unit **12** using data communications network **16**. In a typical configuration, data transceiver **160** receives call delivery information reports from many mobile units **12** and requires a higher capacity design than data transceiver **100** in mobile unit **12**. Antenna **162** receives an incoming call delivery information report from mobile unit **12** and passes the report to transceiver **164**. Controller **166** receives the report from transceiver **164** and passes the report to processor **140** over link **158**. Controller **166** accesses operational software and other data stored in memory **168** to control the operation of data transceiver **160**. Data transceiver **160** also receives call back messages from platform **18** using link **158**, and transmits call back messages to mobile unit **12** using data communications network **16**. The call back message transmitted by data transceiver **160** can be broadcast without the need for location information of mobile unit **12**, or data transceiver **160** can use location information of mobile unit **12** stored at platform **18** to communicate the call back message.

Coupler **146** in platform **18** couples links **170** with links **172**, also referred to in the singular as link **170** and link **172**. Links **170** couple platform **18** with PSTN **38**, other networks **41**, home switch **42**, and other switches **48** to allow callers **36**, desiring to place a call to mobile unit **12**, to connect with platform **18**. Links **172** couple platform **18** with mobile unit **12**. Links **170** and links **172** can include modem and DTMF coder/decoders **174** and **176** or modems **178** and **180**. Platform **18** supports voice calls, voice calls with embedded or interleaved data, and partially or fully encoded data calls using modem/DTMF **174** and **176** or modem **178** and **180**. Coupler **146**, under the direction of processor **140**, couples link **170** with link **172** to complete delivery of a call from caller **36** to mobile unit **12**. Coupler **146**, link **170**, and link **172** include the appropriate hardware and software to control the dialing and call answering capabilities of platform **18**.

Calls to and from mobile unit **12** pass through coupler **146**. Processor **140** controls and monitors coupler **146** and records call information, such as the number and length of calls to each mobile unit **12**, which is recorded in usage tracking system **152**. In this manner, billing system **154** generates bills for use of platform **18**. If several mobile units **12** are associated with a particular company or organization, such as a fleet of trucks, billing system **154** generates a consolidated bill for all calls to and from mobile units **12** installed in the fleet of trucks.

A fraud management system **150** performs an optional security handshake protocol between platform **18** and mobile unit **12** or between platform **18** and caller **36**. This security handshake ensures that only authorized calls are made to and from mobile unit **12** over link **172**. If the security handshake is not executed correctly, then processor **140** disconnects the call through coupler **146**, which greatly reduces costs resulting from unauthorized use of mobile voice communications network **20**. Fraud management system **150** can also perform a similar security handshake on calls received from caller **36** at link **170**. In addition to fraud management, credit card validation system **148** can validate credit card calls made to platform **18**, either from caller **36** or mobile unit **12**. Platform **18** can either perform or not perform either a security handshake or credit card validation on communications with either caller **36** or mobile unit **12**.

In operation, data transceiver **160** receives a call delivery information report from mobile unit **12**. Data transceiver **160** passes the report to processor **140** of platform **18** using link **158**. Processor **140** validates the report using fraud management system **150** and logs the report for usage tracking system **152** and billing system **154**. Processor **140** stores the call delivery information report time-stamped and indexed by mobile unit identification number in memory **142**. Processor **140** can communicate the call delivery information report using link **156** to home switch **42**, other switches **48**, or other platforms **18** in a distributed platform system.

Platform **18** receives a call for mobile unit **12** on link **170**. A caller **36** establishes a connection with link **170** by placing a call, such as a 1+800 call, to platform **18** or by placing a call to home switch **42** or other switches **48**, which then direct the call to platform **18**. Caller **36** enters a telephone number or other mobile unit identification number, which is decoded by modem/DTMF **174** or modem **178** and passed to processor **140**. Processor **140** validates the mobile unit identification number and upon validation accesses the most recent call delivery information report stored in memory **142** indexed by the mobile unit identification number.

Depending on the type of call delivery information retrieved from memory **142**, processor **140** performs additional processing using look-up tables **144** to determine a proper dialing number and method to establish communications with mobile unit **12**. Processor **140** directs coupler **146** to place a call to mobile unit **12** using link **172**. Upon establishing a communications link with mobile unit **12**, coupler **146** couples link **170** connecting caller **36** with link **172** connecting mobile unit **12**.

In another embodiment, platform **18** receives a call from caller **36** at link **170** and generates a call back message to be delivered to mobile unit **12**. The call back message is communicated to data transceiver **160** using link **158**. Data transceiver **160** either broadcasts the message for receipt by mobile unit **12** or directs the message to mobile unit **12** using location information from platform **18**.

The call back message directs mobile unit **12** to call platform **18** or to directly call a number specified by caller **36**. If the call back message requests mobile unit **12** to call platform **18**, then coupler **146** maintains link **170** with caller **36**. Mobile unit **12** calls platform **18** and establishes a connection using link **172**. Coupler **146**, under the direction

of processor **140**, then connects the call from mobile unit **12** on link **172** with the call from caller **36** on link **170**. A ring tone generator **182** can produce an audible ring tone to caller **36** to create the illusion that the call is being directly placed with mobile unit **12**. In addition, mobile unit **12** can call platform **18** without operator intervention. When the connection is established, an audible ring can be generated at mobile unit **12** by output device **124** or handset **96** to inform the operator of the call from caller **36**. By generating a ring tone to caller **36** and a ring tone at mobile unit **12**, call delivery system **10** supports an apparent direct dial call from caller **36** to mobile unit **12**.

Alternatively, the call back message sent by data transceiver **160** to mobile unit **12** over data communications network **16** specifies a direct dial number to caller **36**. In this embodiment, platform **18** disconnects caller **36** on link **170** and mobile unit **12** calls caller **36** directly using the direct dial number provided in the message transmitted by data transceiver **160**.

FIG. **4** is a flow diagram that illustrates a method for delivering a call to mobile unit **12**. The procedure begins when mobile unit **12** generates call delivery information at step **200**. Mobile unit **12** communicates call delivery information to platform **18** at step **202**. Platform **18** performs a security handshake using fraud management system **150** at step **203**. Upon successfully executing the security protocol, platform **18** stores call delivery information at step **204**, and may retransmit call delivery information to other platforms **18**, home switch **42**, or other switches **48**.

Platform **18** receives a call for mobile unit **12** from caller **36** at step **206**. At step **207**, platform **18** performs a security handshake using fraud management system **150** and credit card validation using credit card validation system **148** if caller **36** placed a credit card call. Upon successfully executing the security protocol and validating the credit card of caller **36**, platform **18** acquires and verifies the mobile unit identification number at step **208** and retrieves the most recently reported call delivery information of mobile unit **12** using the mobile unit identification number at step **210**. Platform **18** establishes a communications link with mobile unit **12** using mobile voice communications network **20** at step **212** and performs a security handshake with mobile unit **12** and, optionally, a credit card validation at step **213**. Platform **18** completes the call by coupling caller **36** to mobile unit **12** at step **214**.

FIG. **5** illustrates a method for delivering a call placed by caller **44** coupled to home switch **42** or another caller coupled to other switches **48**. This procedure begins when mobile unit **12** generates call delivery information at step **220** and communicates the call delivery information to platform **18** using data transceiver **100** and data communications network **16** at step **222**. Platform **18** performs a security handshake using fraud management system **150** at step **223**. Upon successfully executing the security protocol, platform **18** stores the call delivery information indexed by time and mobile unit identification number at step **224**. In this embodiment, platform **18** communicates call delivery information to home switch **42** at step **226**, and home switch **42** stores the call delivery information received from platform **18** at step **228**.

Home switch **42** receives a call for mobile unit **12** from caller **44** at step **230**. At step **231**, platform **18** performs a security handshake using fraud management system **150** and credit card validation using credit card validation system **148** if caller **44** placed a credit card call. Upon successfully executing the security protocol and validating the credit card of caller **44**, home switch **42** polls mobile unit **12**, retrieves stored call delivery information, or uses some other method to recognize that mobile unit **12** is out of the service area of home switch **42** at step **232**. Home switch **42** can deliver the call to mobile unit **12** using two different methods. In the first method, home switch **42** delivers the call to platform **18** at step **234** and allows platform **18** to complete the call, as shown in steps **207** through **214** of FIG. **4**.

In the second method, home switch **42** acquires and verifies the mobile unit identification number as entered automatically or manually by caller **44** at step **236**. Home switch **42** retrieves the most recent call delivery information provided by platform **18** using the mobile unit identification number at step **238**. Home switch **42** establishes communications with mobile unit **12** using mobile voice communications network **20** at step **240** and performs a security handshake with mobile unit **12** and, optionally, a credit card validation at step **241**. Platform **18** completes the call from caller **44** to mobile unit **12** at step **242**.

FIG. **6** illustrates a method for delivering a call using a call back message. This procedure begins when platform **18** receives a call for mobile unit **12** from caller **36** at step **250**. At step **251**, platform **18** performs a security handshake using fraud management system **150** and credit card validation using credit card validation system **148** if caller **36** placed a credit card call. Upon successfully executing the security protocol and validating the credit card of caller **36**, platform **18** acquires and verifies a mobile unit identification number entered automatically or manually by caller **36** at step **252**. Platform **18** sends a call back message to data transceiver **160** using link **158**, and data transceiver **160**, as part of or separate from platform **18**, transmits the call back message to mobile unit **12** using data communications network **16** at step **254**.

If the call back message sent from data transceiver **160** to mobile unit **12** specifies a direct dial number for caller **36**, then platform **18** disconnects the call at step **256** and mobile unit **12** uses the direct dial number provided in the call back message to place a call directly to caller **36** at step **258**.

In another embodiment, the call back message requests mobile unit **12** to call platform **18** at step **260**. At step **261**, platform **18** may perform a security handshake using fraud management system **150** and credit card validation using credit card validation system **148** if mobile unit **12** placed a credit card call. Upon successfully executing the security protocol and validating the credit card of mobile unit **12**, platform **18** determines if a ring feature is implemented at step **262**.

If a ring feature is implemented, platform **18** uses ring tone generator **182** to generate an audible ring tone to caller **36** at step **264**. A ring tone can also be generated by output device **124** or handset **96** of mobile unit **12** at step **265**. Therefore, mobile unit **12** can receive a call back message, call platform **18**, and establish communications without user intervention. In such a case, the ring tone generated at mobile unit **12** appears as a direct dial telephone call from caller **36**. Whether a ring feature is implemented or not, platform **18** completes call delivery by connecting the call between caller **36** and mobile unit **12** at step **266**.

Although the present invention has been described with several embodiments, various changes and modifications may be suggested to one skilled in the art, and it is intended that the present invention encompass such changes and modifications as fall within the scope of the appended claims.

What is claimed is:

1. A system for delivering a voice call to a mobile unit, comprising:

a mobile voice communications network;

a data communications network;

the mobile unit comprising:

a positioning receiver, the positioning receiver operable to determine a location of the mobile unit; and,

a data transmitter coupled to the data communications network and the positioning receiver, the data transmitter operable to communicate the determined location as call delivery information using the data communications network, the mobile unit further comprising a mobile voice communications transceiver coupled to the mobile voice communications network; and,

a platform coupled to the data communications network and the mobile voice communications network, the platform comprising a data receiver coupled to the data communications network and operable to receive the call delivery information communicated by the mobile unit, the platform operable to deliver a voice call to the mobile voice communications transceiver of the mobile unit using the call delivery information and wherein the mobile unit determines the location of the mobile unit and communicates call delivery information without user intervention.

2. The system of claim 1, wherein the mobile voice communications network is a cellular telephone network.

3. The system of claim 1, wherein the data communications network is a satellite-based data messaging system.

4. The system of claim 1, wherein the call delivery information further comprises call delivery information received from the mobile voice communications network, the mobile voice communications transceiver further operable to provide the call delivery information to the data transmitter for communication to the platform.

5. The system of claim 1, wherein the platform further comprises:

a first link operable to receive the voice call;

a second link coupled to the mobile voice communications network, the second link operable to establish, in response to the call delivery information received by the data receiver, communications with the mobile voice communications transceiver of the mobile unit; and

a coupler operable to couple the first and second links to deliver the voice call to the mobile unit.

6. The system of claim 1, further comprising a switch coupled to the platform, the switch operable to receive the voice call to the mobile unit, the switch further operable to route the voice call to the platform.

7. The system of claim 6, wherein the switch is the home switch of the mobile unit.

8. A mobile apparatus to receive a voice call from a remote site, the apparatus coupled to a data communications network and a mobile voice communications network, the apparatus comprising:

a positioning receiver, the positioning receiver operable to determine a location of the apparatus;

a data transmitter coupled to the positioning receiver and the data communications network, the data transmitter operable to communicate the determined location as call delivery information to the remote site using the data communications network;

a mobile voice communications transceiver coupled to the mobile voice communications network, the mobile voice communications transceiver operable to receive a voice call delivered by the remote site using the call delivery information; and,

wherein the mobile apparatus determines the location of the mobile unit and communicates call delivery information without user intervention.

9. The apparatus of claim 8, wherein the mobile voice communications network is a cellular telephone network.

10. The apparatus of claim 8, wherein the data communications network is a satellite-based data messaging system.

11. The apparatus of claim 8, wherein the call delivery information further comprises call delivery information received from the mobile voice communications network, the mobile voice communications transceiver further operable to provide the call delivery information to the data transmitter for communication to the platform.

12. A method for delivering a voice call to a mobile unit, comprising:

receiving call delivery information at a mobile unit, wherein the call delivery information comprises position information received from a positioning receiver;

communicating the call delivery information from the mobile unit to a platform using a data communications network;

receiving a voice call for the mobile unit at the platform;

establishing, in response to the call delivery information received from the mobile unit, a communications link between the platform and the mobile unit using a mobile voice communications network;

coupling the voice call to the communications link; and,

wherein the steps of receiving call delivery information and communicating the call delivery information are performed without user intervention.

13. The method of claim 12, wherein the data communications network is a satellite-based data messaging network.

14. The method of claim 12, wherein the mobile voice communications network is a cellular telephone network.

15. The method of claim 12, wherein the step of receiving call delivery information further comprises receiving call delivery information identifying a communications service provider of the mobile voice communications network providing service to the mobile unit.

16. The method of claim 12, wherein the call delivery information further includes a mobile unit identification number, and further comprising the step of storing call delivery information at the platform indexed by the mobile unit identification number.

17. The method of claim 12, wherein the call delivery information includes a mobile unit identification number, and further comprising the step of storing call delivery information at the platform indexed by the mobile unit identification number upon successful verification of the mobile unit identification number by the platform.

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